[redacted]

November 18, 1963

[redacted]

(proposal, first phase)

On the visit of [redacted] and I last June, Mr. [redacted] indicated they would put some of their thoughts on paper and submit them as preliminary stages of proposals.

[redacted] is working on in-house research on automatic target discrimination. one of his two proposals, enclosed, is a feasibility demonstration. The other is ~~fre~~ for a study analysis of the data processing steps required for specific types of targets.

[redacted] work if channeled slightly differently would be of great value and worthy of significant contract support. These proposals however do not define the proper channel.

I discussed his work at some length with [redacted] and [redacted] It appears their approach is best suited to relatively small amounts of data which require many processing steps. Our problem however entails large ~~amonts and~~ amounts of data, 100 million bits, and relatively few processing steps. They believe that problem can best be solved by parallel electron beams, the bundle being equivalent to an image formed on a photo cathode. I strongly recomend that [redacted] look into this concept further.

[redacted] work on [redacted] seemed to indicate previously some promise of achieving automatic stereo registration for continuous scanning of film. Further discussion however indicated it is probably not applicable very directly. They have done a great deal of work on using the recorded navigation and stable platform information for automatic orientation of photos. There is the possibility that this data may be of sufficient accuracy to permit automatic continuous stereo registration. I believe a study of the accuracies obtainable and accuracies required would be significant as pathfinding work.

[redacted]

(3)

AUTOMATIC PHOTO INTERPRETATION FEASIBILITY DEMONSTRATION

Program Objectives

The primary objective of the proposed program is to demonstrate the potential feasibility of performing photo interpretation by means of automatic equipment. For this purpose the objective is to perform a single, carefully selected photo interpretation task by simulated automatic techniques upon a sufficiently large and representative sample of raw imagery data to constitute a convincing demonstration of feasibility.

A further objective is to evaluate potential equipment configurations for performing the same task on a production basis.

Program Approach

The basic approach of this program consists of concentrating upon a single type of task, which can be analyzed and tested exhaustively, rather than attempting to solve the complete range of interpretation problems. The task to be studied should be selected with great care, in conjunction with the contracting agency. It must be sufficiently difficult to constitute a convincing demonstration, but sufficiently constrained to offer reasonable expectation of success.

The approach to designing suitable automatic processing techniques for selected tasks is primarily heuristic and experimental. Known characteristics of the selected target type can be compiled and studied for detectability in image data. (The term "target" is used here generically to denote whatever terrain feature, class of objects or complex it is desired to detect). Important characteristics include dimensions, shape factors, related phenomena (e.g. tracks associated with vehicles), range of reflectances in the visible spectrum (e.g. color and contrast), etc. Characteristics corresponding to other than photographic sensors may also be employed (e.g. IR, radar, etc.) if this is included in the definition of the raw data to be input to the task.

Processing sequences for extracting relevant characteristics of the selected target from imagery will be developed and tested.

Because of the enormous volume of data in real imagery, highly economical techniques must be employed to simulate the developed processing sequences. Two techniques are planned. One involves optics and photography to simulate large decision networks. While tedious, it is valuable for high-resolution data. The second employs an electronic image processing machine currently being completed at [redacted] While of low resolution, this system permits extremely rapid evaluation of processing sequences.

The results of experimental efforts will be used to modify and improve the image processing sequences, based upon failures uncovered. Further testing on examples of the selected target will then be performed.

Because many recognition factors simply involve a repetition of the basic sequence under predictable variations (e.g. orientation of object, contrast, scale) preliminary experiments will be confined to limited conditions.

The developed process will then be extended to general conditions and the process validated on a reasonably large sample of representative imagery containing examples of the selected target. It is estimated that validation can be performed on some 10 to 20 high-resolution examples (each containing a large number of target and non-target images), and 400 to 800 low-resolution single target and non-target cases. Sample imagery for both initial design and validation will be supplied by the contracting agency.

One of the results of the validation will be reasonably firm figures on error and false-alarm rates for the selected task.

Based upon the process developed, production processing system designs will be postulated using state-of-the-art or reasonable extensions of equipment. Processing time for the given problem will then be estimated for the various configurations, and cost-time comparisons prepared.

Discussion

A number of attempts to solve the photo interpretation problem have been made by applying relatively limited imagery processing to a wide range of tasks. It is the purpose of this program to apply image processing in depth to a single representative task. The results can be expected to approach more closely the performance intuitively expected from automatic photo interpretation systems.

Economical experimentation is a keystone of the proposed program. Since no formal procedures are known for synthesis of the decision sequences applicable to image data, experimentation constitutes virtually the only way to test and improve recognition network design.

While simulation of image processing sequences can be performed on conventional computers, it is excessively expensive. The proposed program therefore encompasses the use of two other techniques for conducting the required experiments.

The first, an optical-photographic technique, has been described in the literature. It has been employed at [redacted] to develop recognition sequences for restricted cases of the following targets: passenger vehicles, aircraft, military tanks, urban areas and wooded areas.

The second, an electronic system specifically designed for image processing, is currently being completed at [redacted] Because of its special organization, this very modest machine is at least three times as fast as the IBM 7090 in performing image processing tasks of the required type. It will be available throughout the proposed effort for testing developed image processing programs. STATINTL

Estimates of the magnitude of the validation task proposed in this program can be based upon the cited photographic work conducted at [redacted] TATINTL An estimate of 100 to 200 processing steps (or equivalent decision networks) can be made for performing an "average" task of reasonable complexity. This compares, for example, with a figure of 40 to 60 steps for the restricted vehicle detection example noted, and upon similar figures for the other examples. If high-resolution photographic validation is performed upon 10 to 20 image samples, the number of frames of photography generated therefore ranges from 1,000 to 4,000. For experiments performed upon the electronic image processor, a high estimate of processing time is six minutes for a 100-step process. The corresponding total validation time for the range of decision networks and number of examples is from 40 to 160 hours.

Estimates of processing times on production equipment follow readily once the decision sequence is determined and verified. Both real and hypothetical equipment configurations within the state of the art can be specified, programs written and timing determined with confidence.

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